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AN APPARATUS FOR EVALUATING LIQUID FIRE SUPPRESSANTS[1]

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ABSTRACT

In the search for alternatives to halons in fire suppression, several types of condensed-phase compounds have been identified which may be delivered in droplet or aerosol form. Since currently there is no apparatus designed specifically for screening liquid agents under well controlled experimental conditions, the objective of this work is to design, construct and demonstrate a bench-scale device capable of screening the fire suppression efficiency of liquid agents. The design of the apparatus has been based on a well characterized flame, a means to facilitate the introduction of liquid agents, and a way to generate liquid droplets. A Tsuji-type burner, a porous cylinder used in a counterflow diffusion configuration, was chosen. The geometry of the burner allows for relatively simple analysis of the forward stagnation region. Both wake and enveloped flames can be maintained over a wide range of fuel and oxidizer flows. The flame is easily observed, and critical stages such as the blow-off limit (abrupt transition from an enveloped flame to a wake flame) can be ascertained with ease and high reproducibility. Probing of the flame structure is also possible without intrusive effects on the flame. A small-scale vertical wind tunnel was chosen for the flow facility, and consists of a blower, a flow straightener, a contraction section, and a test section where the burner is placed in cross-flow. This configuration allows for the delivery of a uniform flow of oxidizer to the burner at a low turbulence intensity and also assists in the delivery of liquid agent droplets to the flame. A piezoelectric droplet generator is used to create liquid droplets ($< 250\ \mu m$). The stability limits, which delineate the experimental conditions representing stable blue or yellow enveloped flame and blow-off, have been characterized. The critical blow-off velocity, which is defined as the maximum velocity of the oxidizer stream above which no enveloped flame can be sustained, was similar to that obtained from previous work under same burner diameter. In order to calibrate the burner, the apparatus has been tested with propane and three inert gases: argon, helium, and nitrogen, added to the oxidizer stream. Relative ranking of these three gases was found to be comparable to those from cup-burner tests with helium being the best (in terms of mass fraction added) followed by nitrogen and argon respectively. At a constant oxidizer flow (strain rate), increased fuel flow required increased inert gas flow to blow-off an enveloped flame. The droplet generator is currently undergoing testing with water to refine the final design. In future tests, a Phase Doppler Particle Analyzer (PDPA) will be used to measure droplet sizes, velocities, and number densities near the flame zone. Details of the apparatus design and experimental observations will be presented and discussed.

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